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ANALYSIS OF "PULL-TEST" TOOLS AND THEIR LIMITATIONS AS APPLIED TO TERMINAL JUNCTION BLOCKS

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April 1983

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16. ABSTRACT

Discovery of unlocked contacts in Deutsch Block terminal junctions in Solid Rocket Booster flight hardware prompted an investigation into "pull-test" techniques to help insure against possible failures. In this paper, internal frictional forces between socket and pin and between wire and grommet were examined. Pull-test force must be greater than internal friction yet less than the crimp strength of the pin or socket. For this reason, a 100 percent accurate test is impossible. Test tools were evaluated. Currently available tools are adequate for "pull-testing."

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INTRODUCTION

Discovery of unlocked contacts in Deutsch Block terminal junction in Solid Rocket Booster flight hardware prompted an investigation of testing procedures and tools. Since Deutsch Blocks have rear-access contacts, a "pull-test must be utilized. The "pull-test" force is bounded by a minimum force (equivalent to the friction within the pin-socket system) and a maximum force (the crimp strength of the pin or socket upon the wire). Since the "pull-test" forces are bounded, a 100 percent accurate test is impossible. For example, some contacts might require a "pull-test" at a higher value than crimp strength permits or at a lower value than frictional forces permit; thus, that test will either be inaccurate or impossible to perform. Crimp strength values were already available. Frictional forces were determined by laboratory test. Existing tools were evaluated to determine if they would meet test criteria. Two tools, Russtech Engineering and McDonnell-Douglas, were evaluated by laboratory tests. The results are contained herein.

DEUTSCH BLOCK FRICTIONAL ANALYSIS

Procedure

Size 22 Deutsch Blocks were used in testing because most problems have been encountered with that size. Twenty-two guage teflon wire was used in testing so that maximum frctional values could be calculated for size 22 blocks. Deutsch Blocks were modified in two ways: (1) The spring clip locking mechanism was broken to prevent interlocking of the pin and socket; (data set one); and (2) a small drop of solder was placed in the bottom of the socket to limit insertion depth and thus to prevent interlocking (data set two). Two Deutsch Blocks, each containing ten contacts, were used for each data set.

An Instron Stress-Strain Testing machine was used to "pull-test" the Deutsch Blocks. The blocks were locked into a variable angle vise so that the angle of pull could be varied between 0 and 90 deg. Thus, frictional force was determined as a function of pull angle. Data was recorded on the chart recorder. Three pulls were conducted at each angular setting. If a large variation within a data point occurred, additional pulls were taken to insure accuracy. After pulling all the wires from each Deutsch Block, the wires were reinserted at random. Two sets of data were collected, one from the block with broken locks and one from the set with soldered sockets (Fig. 1).

Results

The graph in Figure 2 was complied from both data sets. It is clear that from 0 to 40 deg, most of the friction occurs between the socket and pin. This portion of the function is almost linear. From 40 to 90 deg most of the friction occurs between

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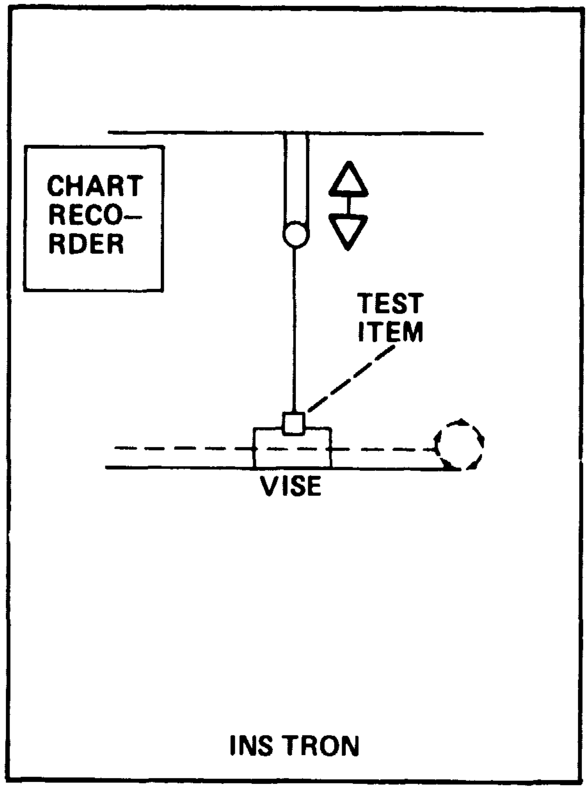

Figure 1. Test Apparatus

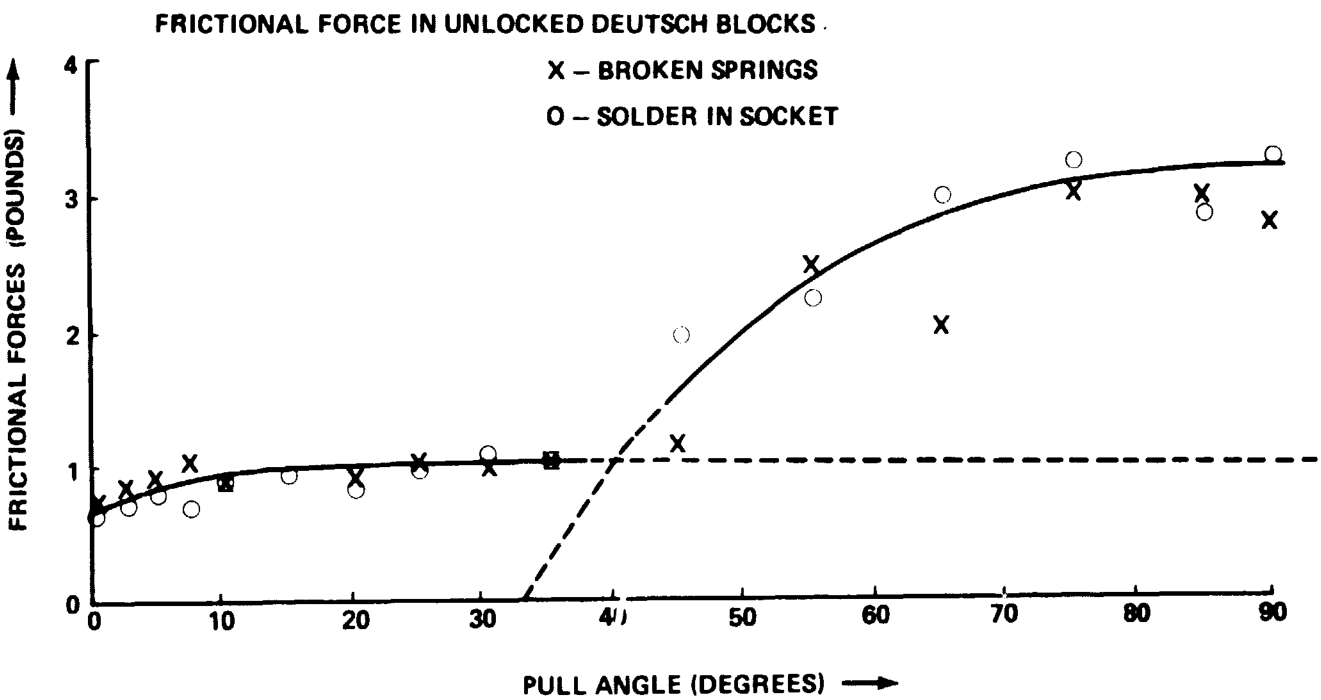

Figure 2. Frictional Force in Unlocked Deutsch Blocks

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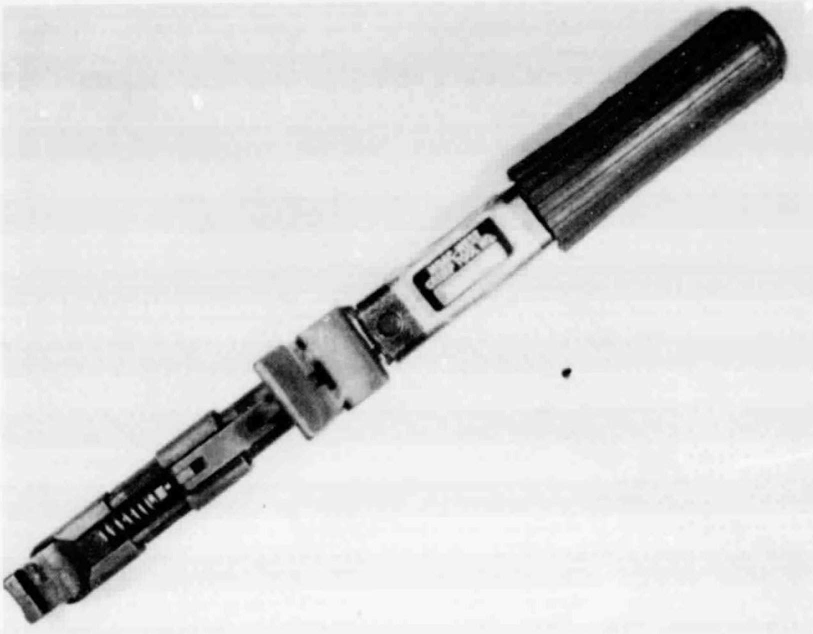

Figure 3. Frontal View of McDonnell-Douglas Tool with Gripper Jaw Open.

Figure 4. Frontal View Gipper Jaw Closed

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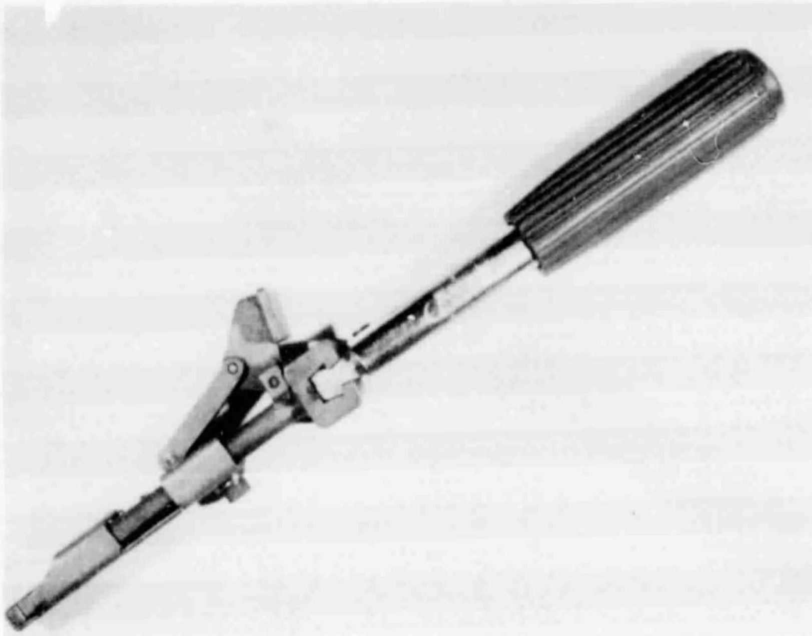

Figure 5. Lateral View of the McDonnell-Douglas Tool.

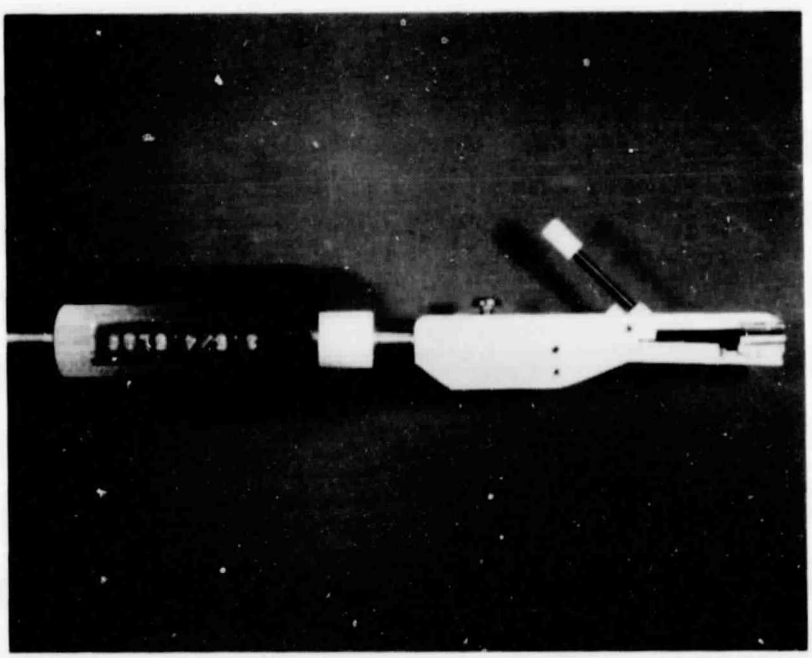

Figure 6. Lateral View of the Russtech Tool.

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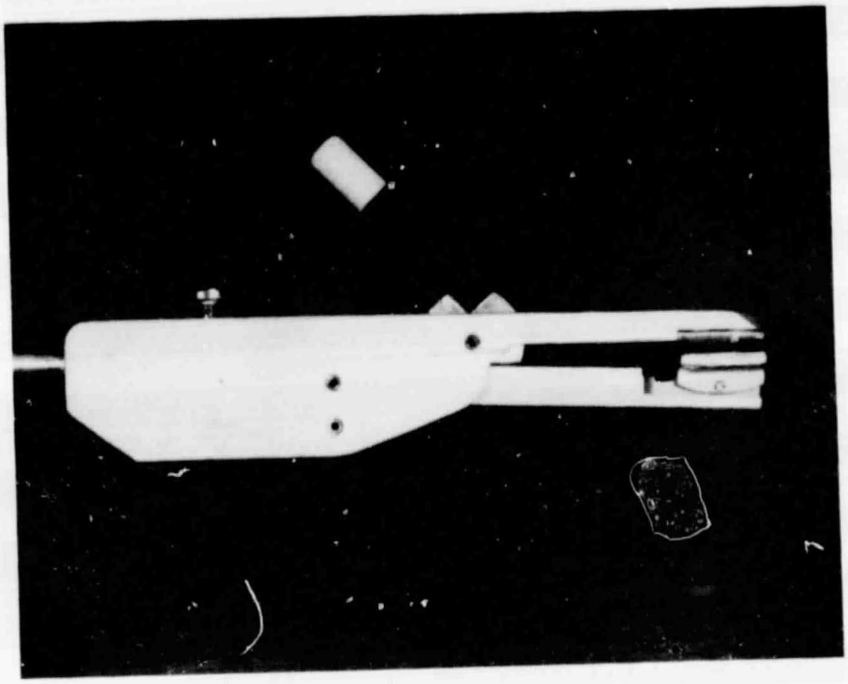

Figure 7. Lateral View of the Gripper Jaw of the Russtech Tool.

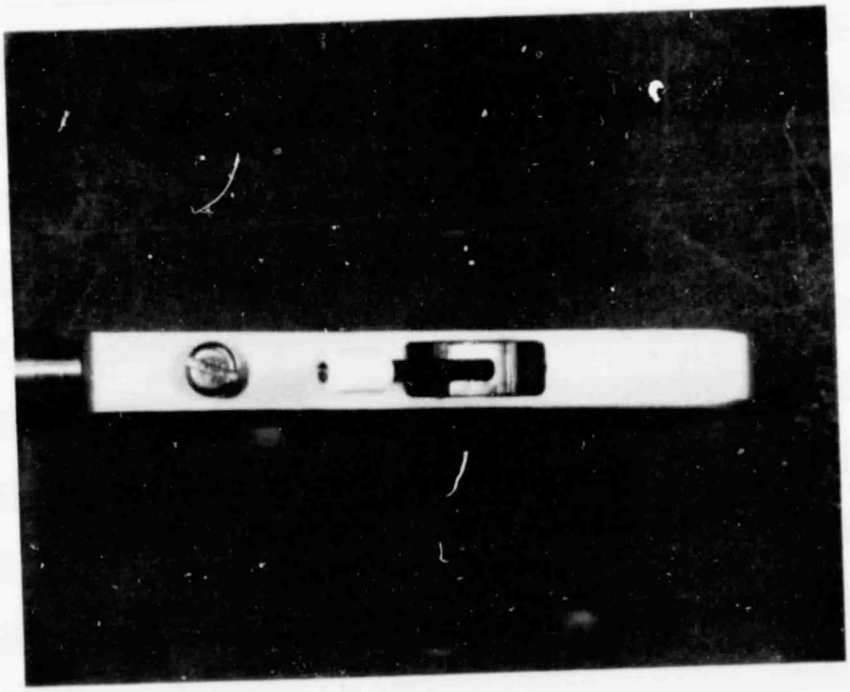

Figure 8. Frontal View of the Gripper Jaw of the Russtech Tool.

the rubber grommet and the wire. The X's are the actual data points for the block with the broken locks. The O's are the actual data points for the block with soldered sockets. Both data sets are surprisingly close. The solid lines are averages of both data sets, and the dotted lines approximate the continuance of each function if the two functions were not added together.

Finally, the maximum friction occurred within a size 22 Deutsch Block with 22 gauge teflon wire was 3 lb (the minimum "pull-test" boundary).

TOOL EVALUATION

Description of Tools

Two tools (a prototype from Russtech Engineering and a "shop-made' tool from McDonnell-Douglas) were considered. Figures 3 through 8 are photographs of the tool.

The Russtech tool has a factory set release mechanism in the handle. Attached to the handle is a set of gripper jaws. The release mechanism can be ordered at any setting (the one evaluated was set at 3.5 to 4.5 lb). Jaw tension may be varied by a set screw adjustment. The production model of this tool would probably have two or three sizes of jaws. This tool uses an in-line or parallel pull. This prototype was designed for smaller wire; but it may be used on wire as large as 12 gauge.

The McDonnell-Douglas tool is a "break-over" torque tool modified with a set of jaws. The wire is pulled perpendicularly to the tool handle. The tool is preset to "break" at 5.4 lb. Jaw tension may also be varied. Tension was set for larger wire in our test.

A pull angle variation effects test and a wire slippage test were conducted. The Instron Testing machine was used for both tests.

Angle Variation Test

The tool to be tested was locked into a variable angle vise. Twenty-two gauge teflon wire was used for the Russtech test. Twelve gauge teflon wire was used for the McDonnell-Douglas test. At each angular setting, the wire specimen was pulled until the tool tripped or the wire slipped in the gripper jaws. Three trials were taken at each setting so that an average value could be established. The Russtech tool was tested with the angle varied in the parallel, perpendicular and 45 deg planes relative to the jaw surfaces (Figs. 9 and 10).

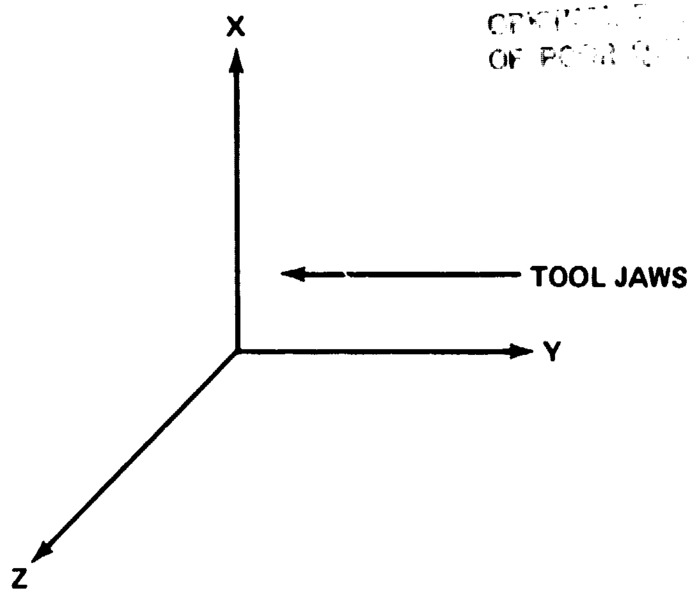

Figure 9. Coordinate System

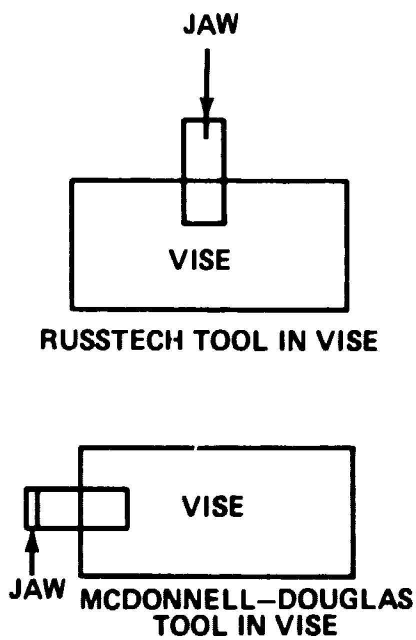

Figure 10. Vise Arrangement

Testing apparatus limited the McDonnell-Douglas tool to parallel plane testing. Average values are in the tables below:

Russtech Tool

Angle (deg)	Parallel Plane	Perpendicular Plane	45 deg Plane
0	3.9 (lbs)	3.9 (lbs)	3.9 (lbs)
5	4.6	4.5	4.7
10	5.3	5.4	5.7 - slips
12 1/2	5.7 - slips	5.7 - slips	-
15	-	-	-

McDonnell-Douglas Tool

Angle (deg)	Parallel Plane (lbs)
0	5.4
5	5.4
10	5.4
12 1/2	5.4
15	5.4
25	5.4
35	5.5
45	6.5

Wire Slippage Test

Wire specimens of different sizes and insulation varieties were pull tested, using the Instron, to determine at what pull strength wire slippage occurred in the gripper jaws. Three trials were used to determine an average value. The pull was direct, parallel to jaws on both tools. On the Russtech tool one set (3 trials) of data was taken with minimum jaw tension and one with maximum jaw tension. One set of data was taken on the McDonnell-Douglas tool.

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Russtech Tool

Insulation	Size	Minimum Retention (lbs)	Maximum Retention (lbs)
Kapton	20	6.93	9.46
	22	5.9	9.5
	24	6.06	9.0
PVC	16	7.0	9.03
	20	8.0	11.0
	22	7.8	9.73
	24	6.8	7.83
Teflon	12	9.1	11.4
	14	7.2	8.9
	16	6.1	7.63
	18	6.46	7.46
	20	5.5	6.56
	22	5.6	5.6
	24	4.03	5.23
	26	4.53	4.56

McDonnell-Douglas Tool

Insulation	Size	Maximum Retention (lbs)
Kapton	20	6.9
	22	5.4
	24	6.5
PVC	16	7.9
	20	11.3
	22	8.65
	24	7.65
Teflon	12	9.15
	14	6.6
	16	6.4
	18	6.25
	20	5.8
	22	4.9
	24	3.8
	26	4.6

CONCLUSIONS

Since "pull-tests" forces are bounded by a minimum (internal friction) pull force and a maximum (crimp strength) pull force, no "pull-test" will be 100 percent accurate. The McDonnell-Douglas tool is not as dependent upon pull angle as is the Russtech tool. The Russtech tool is smaller; therefore it can be easier to use in small spaces. Both tools are adequate for "pull-testing" Deutsch Blocks.

APPROVAL

ANALYSIS OF "PULL-TEST" TOOLS AND THEIR LIMITATIONS AS APPLIED TO TERMINAL JUNCTION BLOCKS

By James Lee Smith

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

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